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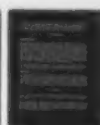
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EVALUATION OF A RED-SILICONE-COATED VISUAL
APPROACH SLOPE INDICATOR (VASI) LENS

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, NEW JERSEY

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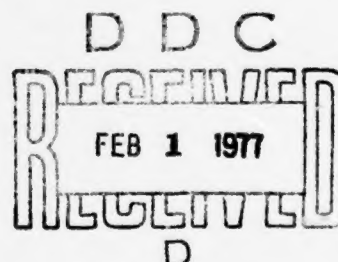
**EVALUATION OF A RED-SILICONE-COATED VISUAL
APPROACH SLOPE INDICATOR (VASI) LENS**

Raymond E. Johnston



January 1977

FINAL REPORT



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16. Abstract <p>The subject effort was to test and evaluate the results of a new method of producing the red/white color-coded signal used in a Visual Approach Slope Indicator (VASI) system. The present system utilizes a split lens assembly to produce the color coding, which consists of a clear lens segment and a red lens segment, the clear being somewhat smaller than the red, to construct one single VASI lens assembly. A new method of providing the signal was developed by coating the upper part of a circular clear lens with a heat-resistant red-silicone-pigment paint, leaving the lower part clear to transmit the white signal. Laboratory and field tests conducted on the coated lens resulted in no appreciable deterioration of the red signal; therefore, it was determined that this method of providing the signal was comparable to the split lens assembly. The results of the tests indicate that this method of producing the signal would be suitable for present and future VASI systems.</p>			
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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH								
in	inches	2.5	centimeters	cm	millimeters	0.04	inches	in
ft	feet	30	centimeters	cm	centimeters	0.4	inches	in
yd	yards	0.9	meters	m	meters	3.3	feet	ft
mi	miles	1.6	kilometers	km	kilometers	1.1	yards	yd
AREA								
in ²	square inches	6.5	square centimeters	cm ²	square centimeters	0.16	square inches	in ²
ft ²	square feet	0.09	square meters	m ²	square meters	1.2	square yards	yd ²
yd ²	square yards	0.8	square meters	m ²	square kilometers	0.4	square miles	mi ²
mi ²	square miles	2.6	square kilometers	km ²	hectares (10,000 m ²)	2.5	acres	ac
MASS (weight)								
oz	ounces	28	grams	g	grams	0.035	ounces	oz
lb	pounds	0.45	kilograms	kg	kilograms	2.2	pounds	lb
	short tons (2000 lb)	0.9	tonnes	t	tonnes (1000 kg)	1.1	short tons	
VOLUME								
teaspoon	teaspoons	5	milliliters	ml	milliliters	0.03	fluid ounces	fl oz
Tablespoon	tablespoons	15	milliliters	ml	liters	2.1	pints	pt
fl oz	fluid ounces	30	milliliters	ml	liters	1.06	quarts	qt
c	cups	0.24	liters	l	liters	0.26	gallons	gal
pt	pints	0.47	liters	l	cubic meters	35	cubic feet	ft ³
qt	quarts	0.95	liters	l	cubic meters	1.3	cubic yards	yd ³
gal	gallons	3.8	liters	l	TEMPERATURE (exact)			
ft ³	cubic feet	0.03	cubic meters	m ³	°C	Celsius temperature	Fahrenheit temperature	°F
yd ³	cubic yards	0.76	cubic meters	m ³	TEMPERATURE (exact)			
TEMPERATURE (exact)								
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C	°C	9/5 (then add 32)	Fahrenheit temperature	°F

*1 in = 2.54 (exact). For other exact conversions and more detailed tables, see NBS Misc. Pub. 250, Units of Weights and Measures, Price \$2.25, SO Catalog No. C13.1U-286.

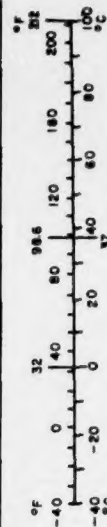


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INTRODUCTION

PURPOSE.

The purpose of this activity was to evaluate the results of a new method of producing the red/white color-coded signal used in a Visual Approach Slope Indicator (VASI) system by use of a red-silicone-pigment coating applied to the upper portion of a circular clear lens.

BACKGROUND.

The VASI is a navigational aid that provides a visual glide slope indication for a pilot during his approach to the runway touchdown zone under visual flight rules (VFR) weather conditions.

This signal is provided to the pilot by the transmission of a pair of red/white color-coded signals located approximately 15 meters off the edge of the runway, having a longitudinal separation between light signals of approximately 150 meters. The light signals are aligned so as to present to the pilot on approach a white/red signal when on the proper glide slope, a white/white signal when above the glide slope, and a red/red signal when below the proper glide slope.

The system is a valuable aid as a method of defining a safe visual approach slope clearance over obstructions that cannot themselves be obstruction lighted. It further provides aiming-point information, thus alleviating the possibility of over-shoots and undershoots. The number of light units or boxes that make up a VASI system varies between 2 and 16 boxes at airports where straight-in approaches could be made.

DESCRIPTION OF EQUIPMENT.

This effort is concerned with the evaluation of a silicone-coated lens assembly. The present lens assembly utilizes a split lens system, with the upper portion red and the lower portion clear. The manufacture of this type of lens assembly is time consuming and costly, in part, because the red portion is larger in area than the clear; therefore, that part of the red lens which is not used is wasted.

A new method of providing the red signal has been developed by coating the upper portion of a circular clear lens with a heat-resistant red-silicone-pigment paint. Several of these lenses were delivered to NAFEC for photometric and environmental testing to determine if the lens will meet the color requirements for a VASI system.

Figure 1 is a photograph exhibiting both the split lens assembly shown on the left and the coated lens shown on the right. It can be seen in the photograph that the red segment is somewhat larger than the clear. When installed in the

system, the red segment is positioned above the clear so that when both the upwind box, the one furthest from the threshold, and the downwind box, the one near the threshold, are properly aligned, the VASI will transmit the proper signal for a fly-up, on glide slope, or a fly-down indication.

TEST PROCEDURES

LABORATORY TESTS.

Silicone-coated lenses were delivered to the Metrology Laboratory at the National Aviation Facilities Experimental Center (NAFEC) for optical testing. The tests consisted of chromaticity measurements and light distribution measurements of the red portion of the lens. The tests were conducted using three 200-watt PAR 64, 6.6-ampere General Electric Quartzline® lamps at maximum rated output. The lamps and lenses were installed in a standard three-lamp VASI unit. The optical tests were conducted before and after a 31-day life test period and a 6-month field test period to determine if the red-silicone-pigment coating remained within the CIE color coordinate boundaries, $x=0.680/0.695$ $y=0.296/0.316$, with a transmittance net loss less than 10 percent after the lens stabilized at normal operating temperature.

The light distribution measurements were conducted to determine if there was any appreciable change in output of the red signal between the initial and final tests which would indicate a degradation of the silicone paint.

FIELD TESTS.

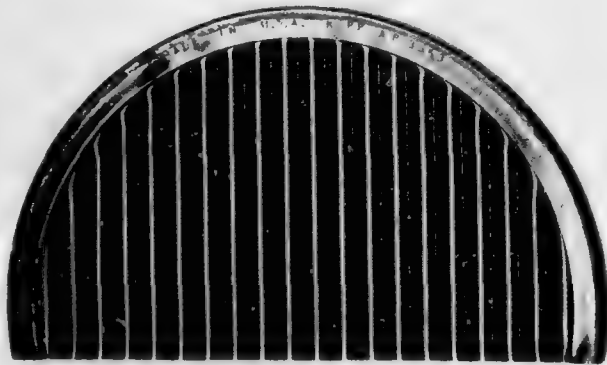
The field tests were conducted primarily to determine what effect actual weather conditions would have on the pigment coating of the lens, such as blistering or peeling, due to natural environmental conditions. The three lenses were installed in a VASI unit located adjacent to runway 13 at NAFEC. The tests were run for a period of 6 months. At the end of the test period, the lenses were returned to the Metrology Laboratory to conduct the final optical tests.

TEST RESULTS

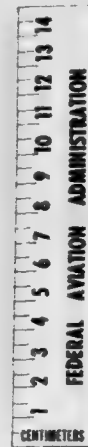
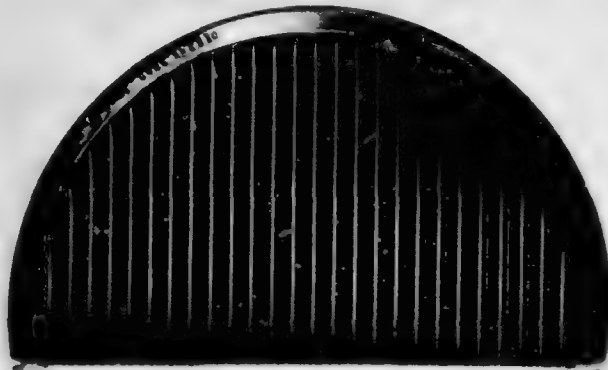
Table 1 show the results of the chromaticity measurements for the initial and final tests. It can be seen that the transmittance (T) remained unchanged for the tests.

The table indicates a slight change in the x and y coordinates for each of the three lenses tested. When removed from the field it was noted that the lenses had experienced minor scratches or abrasions that were apparently caused by small field creatures entering the VASI unit or possibly dirt and sand blown into the VASI unit by jet aircraft.

SPLIT LENS



RED SILICONE COATED LENS



76-31-1

FIGURE 1. COMPARISON BETWEEN SPLIT LENS ASSEMBLY AND RED-SILICONE-COATED LENS

TABLE 1. TRANSMITTANCE (T) OF RED SECTORS OF SILICONE-COATED VASI FILTERS AND CIE CHROMATICITY COORDINATES x AND y FOR THE INITIAL AND FINAL TEST PERIODS

Filter No.	Initial Measurements			Final Measurements		
	T	x	y	T	x	y
1	0.15	0.684	0.310	0.15	0.683	0.311
2	.17	.679	.313	.17	.677	.314
3	.17	.680	.312	.17	.680	.313

NOTE: x coordinate minimums should be 0.680. Two lenses above are within the 0.680 minimums, and one lens below minimum.

During the initial chromaticity measurements, one of the lenses did not quite meet the color specifications as required. This was evidently due to an insufficient amount of coating applied to the lens during the processing.

The curves plotted on the graph in the appendix, figure A-1, were derived from the tables A-1 and A-2, the initial and final distribution measurements. The output in candelas versus the vertical distribution in degrees was taken at the midpoint or zero azimuth as shown in the tables. There was a slight degradation of the coating, as can be seen in figure A-1.

Because there was no appreciable change in color, as evidenced by the laboratory and field tests, it was decided that flight tests of the system were unwarranted. However, during several flight tests of other activities at NAFEC observers requested to look at the VASI on runway 13. Their opinions were that there was no difference between the red signal of the standard VASI and that of the coated VASI.

SUMMARY OF RESULTS

As evidenced from the results of the laboratory tests and the field tests, the coated lens experienced negligible degradation. There was no peeling or blistering of the paint due to exposure to changes in atmospheric conditions when installed in the field. The minor scratches or abrasions of the coating were determined negligible and not contributable to any change in color. Visual observations of the system showed that there was no detectable difference in signal output.

CONCLUSION

It was concluded from the results of the laboratory and field tests performed on the silicone-coated VASI lens that this method of providing a red signal for a standard VASI was found satisfactory and may be used in lieu of the standard split lens assembly.

APPENDIX A

PHOTOMETRIC CHARACTERISTICS OF RED-SILICONE-COATED VASI LENSES BEFORE AND AFTER A 6-MONTH FIELD TEST AND A 31-DAY LABORATORY TEST PERIOD

Comparison between initial and final vertical distribution curves plotted from the tabular data of tables A-1 and A-2 is made. Curves are taken through zero azimuth for figure A-1.

TABLE A-1. RED-SILICONE-COATED LENS, INITIAL MEASUREMENTS OF INTENSITY IN CANDELA VERSUS AZIMUTH AND ELEVATION ANGLES IN DEGREES

AZIMUTH	ELEVATION					
	-5.0	-4.0	-3.0	-2.0	-1.0	.0
-13.0		20	103	185	309	309
-12.0		20	103	206	391	350
-11.0		41	123	267	494	453
-10.0	20	41	144	391	700	576
-9.0		61	226	679	1091	824
-8.0	20	82	453	1339	1833	1174
-7.0		123	927	2451	2822	1689
-6.0		185	1627	4017	4037	2224
-5.0		226	2286	5644	5232	2801
-4.0		267	2863	6859	6262	3337
-3.0	20	288	3172	7725	7107	3708
-2.0	20	309	3275	8178	7642	3975
-1.0		329	3296	8363	7992	4161
.0	20	329	3337	8425	8157	4284
1.0		309	3378	8466	8198	4305
2.0		329	3296	8404	8116	4264
3.0		309	3213	8240	7992	4161
4.0		309	3110	7951	7704	3975
5.0		288	2945	7416	7107	3708
6.0		267	2575	6489	6200	3254
7.0		206	2018	5047	5026	2698
8.0		164	1380	3646	3790	2121
9.0		103	782	2245	2678	1586
10.0		82	370	1236	1812	1194
11.0		61	226	638	1153	865
12.0	20	61	164	350	741	638
13.0		41	123	247	494	453
14.0		41	123	206	370	350

(-) Sign on azimuth reads degrees that lens is turned right of photometer.
No sign on azimuth indicates zero turn through 14° to the left of photometer.

(-) Sign on elevation indicates a depression of the lens below the horizontal.

TABLE A-2. RED-SILICONE-COATED LENS, FINAL MEASUREMENTS OF INTENSITY IN CANDELA VERSUS AZIMUTH AND ELEVATION ANGLES IN DEGREES

AZIMUTH	ELEVATION					
	-5.0	-4.0	-3.0	-2.0	-1.0	.0
-13.0	20	41	92	175	319	298
-12.0		41	113	216	381	360
-11.0		61	123	278	525	463
-10.0		51	154	401	731	597
-9.0	10	72	236	731	1122	834
-8.0	10	82	463	1369	1977	1225
-7.0	10	123	1019	2678	3059	1709
-6.0	10	185	1689	4315	4253	2276
-5.0	10	288	2441	6077	5397	2884
-4.0	10	278	3028	7251	6550	3440
-3.0	10	309	3316	8064	7498	3831
-2.0	20	319	3419	8538	8003	4120
-1.0	20	350	3471	8724	8301	4326
.0		339	3532	8785	8476	4430
1.0	10	350	3574	8837	8476	4470
2.0	20	339	3522	8755	8425	4439
3.0	10	339	3460	8579	8281	4315
4.0	20	319	3388	8332	7941	4150
5.0		309	3223	7838	7323	3852
6.0	10	298	2873	6870	6406	3429
7.0		236	2338	5489	5253	2945
8.0	10	175	1658	3893	3965	2235
9.0	30	133	916	2317	2822	1730
10.0	10	92	453	1256	1998	1277
11.0		61	236	628	1225	937
12.0	10	61	164	381	762	679
13.0	10	51	144	267	535	494
14.0	10	51	113	216	391	339

(-) Sign on azimuth reads degrees that lens is turned right of photometer.
No sign on azimuth indicates zero turn through 14° to the left of photometer.

(-) Sign on elevation indicates a depression of the lens below the horizontal.

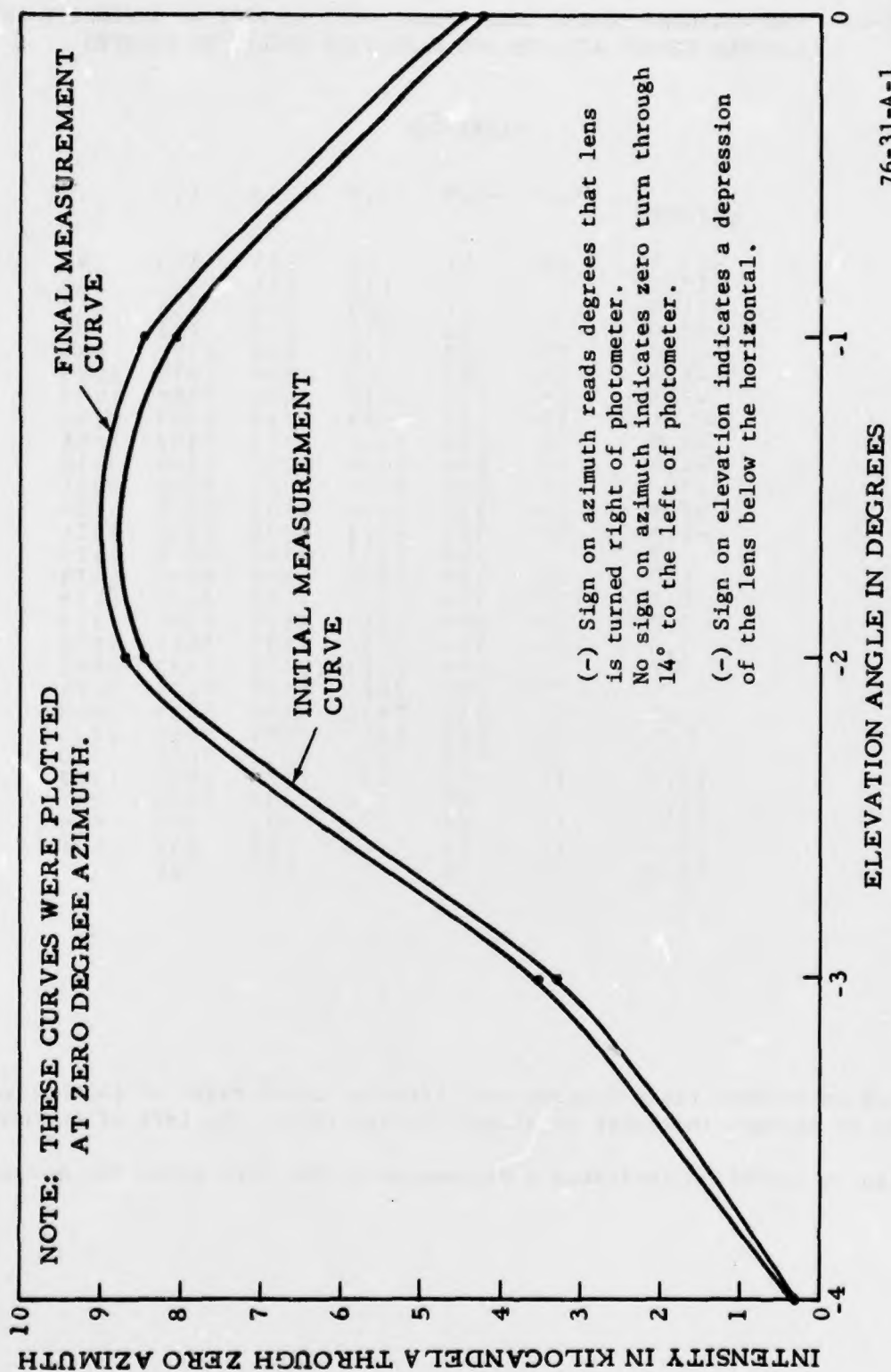


FIGURE A-1. VERTICAL DISTRIBUTION CURVE AT ZERO DEGREES AZIMUTH FOR INITIAL AND FINAL TESTS